Chapter 9

Data Acquisition and Triggers

The data acquisition and trigger needs for BRAHMS are not expected to pose major technical challenges. Both can be fulfilled by a fairly conservative design.

9.1 Data Acquisition

The BRAHMS data acquisition is a UNIX/VME based system which will facilitate the readout and processing of data from various detector subsystems. It is planned to record $\approx$50 central events/sec and 200 spectrometer events/sec from all impact parameters. The data acquisition also provides for run control and control and monitoring of the operation of various detectors and related components.

The heart of the system consists of a VME processor element farm residing in several VME crates. Most of these processors are used for reading event fragments from front-end crates and have various interfaces to CAMAC, the front-end electronics (FEE) for the BRAHMS TPC's and centrality detector, and Fastbus. A VME crate is dedicated to monitoring and controlling various detectors and devices. To facilitate collection of various event fragments in parallel and to reduce VME traffic one processor is dedicated and directly interfaced to each CAMAC and Fastbus crate. Several processors will be interfaced to the centrality detector and TPC front-end electronics through high-speed optical fiber links for readout and zero-suppression. Several VME processors with SCSI-2 and ethernet interfaces perform event building, reformatting and data logging tasks.

Front End Electronics Interface

The front-end electronics for BRAHMS consist of CAMAC and Fastbus and are likely to use integrated electronics being developed for STAR or PHOBOS as well. FEE for the centrality detector for BRAHMS are likely to be an adaptation of similar FEE being developed for PHOBOS. The TPC read-out electronics cards which are being developed for STAR and similar cards being used in the NA49 Experiment are being considered for the TPC's in BRAHMS. These modules provide both timing and dE/dx information and have a relatively low incremental cost of production. It should be possible to modify and adapt these modules for the BRAHMS TPC's.

All front-end electronics are interfaced to VME and have dedicated VME-based intelligent controllers. We have developed intelligent VME interfaces to CAMAC as well as Fastbus which permit parallel readout of event fragments from various detectors for E866. These interfaces can be used in the current state or modified to accommodate higher event rates. The CAMAC interfaces consist of commercial VME processor boards equipped with memory-mapped interfaces to CAMAC crate controllers. The interface to Fastbus is through a VME slave interface to multiple Fastbus segment managers via fiber-optic links. The Fastbus interface could be modified to provide for multiplexed block transfer (MBLT) capability to enhance the VME data transfer rates.

The detectors proposed for BRAHMS consist of $\approx$15K channels, most of which have no hits in a typical event. The data from the TPC FEE constitute the majority of the raw data in BRAHMS. At a rate of 250 events/sec over 200 MB of raw data have to be processed per second. These data must be substantially reduced before logging. A VME interface to the TPC FEE will be designed. One VME processor module is dedicated for readout and zero-suppression of data from 16 FEE boards (512 channels). A daughter board interfaces directly to the processor module. This board interfaces with a control module via a fast optical link. The control module interfaces to 16 FEE boards and performs the readout of all boards once an event has been digitized. Zero-suppression and further reduction of data will be performed on the VME processor. Zero-suppression of the TPC data could in principle be performed, in earlier stages of readout, on the control module. This would however require a larger development effort and debugging time; also later enhancements would require major modifications, while a commercial processor board can easily be replaced with a more powerful processor. There may also be a need to develop VME interfaces to the FEE for the centrality detector if an appropriate interface is not available. The decision to develop such an interface will be made in the next year pending the final design of such interfaces by other collaborations.

DAQ Control and Software

The BRAHMS data acquisition is a UNIX/VME64 based system. All code for the host and the majority of the VME data acquisition code will be written in C/C++. Minimal amounts of code will be written in assembly language. The VxWorks real-time development environment will be used for the development of code running on VME processors. SQL will be used for database access through RHIC computing facilities.

Motif graphical user interfaces (GUI) will be developed on UNIX workstations (e.g. SPARCstation 10) for DAQ run control and for monitoring and controlling various detectors. The majority of the code for the GUI will be generated using a commercial package such as Builder Xcessory. The host workstation is interfaced to VME modules over ethernet. Data acquisition on the VME crate could be centered around PowerPC (or ALPHA) based VME-resident CPUs with SCSI-2 and ethernet interfaces. Event building, reformatting, and tape logging will be performed on these processors. The present design can accommodate logging data to multiple tape drives via independent VME processors. However, data could also be sent to dedicated workstations via fast VME/(SBUS/PCI) buses for further processing and/or data logging. A small sample of data could be monitored by accessing the sample over the network: alternately fast dedicated links could be used to access a much larger sample which is especially useful in the initial debugging/setup stages of the experiment. VME processors with MBLT capability running the VxWorks real-time operating system will be employed in the DAQ system. VxWorks seems to be the best choice as a real-time VME development environment; it is the VME operating system most widely used in nuclear physics and HEP experiments and is used by EPICS. Another commercial real-time VME development environment, VRTX from Ready Systems, was considered but previous versions of VRTX have serious problems and support of this product is very limited.

Slow Controls

Unlike the present situation with AGS experiments, access to the experimental area and various detectors will be very limited during RHIC operation. There are a relatively large number of components that require monitoring and remote operation in BRAHMS. These include moving the spectrometers, setting and monitoring the magnets, setting and monitoring silicon voltage/current for the centrality detector, setting and monitoring various high voltages, monitoring and controlling the tracking detector gas flow, and generating alarms. BRAHMS, therefore, requires a reliable and flexible control system capable of handling a diverse set of interfaces. The EPICS control system satisfies our requirements and fits well with the overall DAQ design. Data acquisition, detector control, and monitoring of events and hardware form a distributed and integrated environment. One or more workstations can be used for run control, control of hardware and monitoring of various detector systems and data; this will be accomplished by implementing a client/server model with RPCs using TCP/IP.

Schedule

Due to the rapid progress in computer hardware the final selection of UNIX-based workstations, VME-resident CPU's, and tape drive technology will be delayed until 1997. The DAQ software development effort will begin when funding becomes available and should be complete and partially tested by 1998. All hardware prototypes will be built by 1997 and tested by 1998. The development and testing of the control system will begin once funding is available and should be complete prior to the availability of major detector components. The completion of the DAQ system in a timely manner is only possible if enough funds (approximately one third of the cost for the DAQ) are incrementally available before 1997.

9.2 Triggers

The BRAHMS detector electronics and readout consists of both conventional TDC's and ADC's in CAMAC and Fastbus as well as integrated front end electronics for the TPC's and the centrality detector. Multiple trigger levels are required for BRAHMS.

The lowest level trigger (LVL0) will be formed by requiring a coincidence between signals from the RHIC clock and from the beam-beam counters located on opposite sides of the interaction point. This will be used to start the triggering system and the integrated electronics. The LVL0 trigger also constitutes a minimum-bias trigger for which a sample of events will be recorded.

The main first level trigger (LVL1) will also use the multiplicity detector, where several windows will select a range of reactions from peripheral to central collisions. This will also be used for measurements in the midrapidity spectrometer which, for Au+Au running, does not require a specialized trigger to obtain sufficient rates and statistics.

For the forward spectrometer, on the other hand, a track-selection trigger is needed for larger angles ($\theta > 5°$) and/or non-central events. This can be formed by requiring hits in T3, T4, T5 and H2 as necessary conditions for identifying a track through the D3-D4 magnet system. More detailed studies are needed to determine if this will be sufficient to obtain the desired rates. The trigger could, e.g., be improved by correlating valid combinations of wire-hit positions in the different chambers, thereby suppressing background tracks which do not originate from the interaction region.

Future Plans

For running with lighter ions and protons it is desirable to have more refined spectrometer triggers. Two MWPC's are planned for inclusion in the midrapidity spectrometer trigger. The chambers will be mounted between the magnet and the TPCs. Their sizes will be 40 cm$\times$15 cm and 45 cm$\times$20 cm, respectively. Anode to anode wire spacing will be 0.5 cm. Each chamber will have two planes with different orientations in the x and y directions. Planes in y-direction can be used to form a trigger selecting particles from the collision diamond. When charged particles from the collision diamond go through the spectrometer, the positions of hit wires in the two chambers and the beam axis form a straight line. This condition can be programmed in a lookup-table as a LVL1 trigger. More elaborate triggers can be formed in LVL2 by utilizing information on time-of-flight, hit positions on the trigger chamber in the x-direction, and the vertex point from the beam-beam counters. From the above hit positions, a rough estimate of the momenta for the charged particles can be obtained. In combination with time-of-flight information, on-line particle identification is achievable for rare particle production, resonance production, and two-particle correlations at small relative momentum.